

**TECHNIQUE FOR MAINTAINING SECURE NETWORK CONNECTIONS**

**FIELD OF THE INVENTION**

The present invention relates generally to  
5 telecommunications and, more particularly, to a technique for  
maintaining secure network connections.

**BACKGROUND OF THE INVENTION**

IP Security (IPsec) is a security architecture for internet  
10 protocol (IP) that includes a set of protocols developed by the  
Internet Engineering Task Force (IETF) to support secure  
exchange of packets at the IP layer. IPsec provides security  
services by enabling a system to select required security  
protocols, determine the algorithm(s) to use for the service(s),  
15 and put in place any cryptographic keys required to provide the  
requested services. IPsec uses two protocols to provide traffic  
security: Authentication Header (AH) and Encapsulating Security  
Payload (ESP). For IPsec to work, the sending and receiving  
devices typically share a public key which is handled through  
20 the Internet Security Association and Key Management Protocol  
(ISAKMP).

A Security Association (SA) is a security-protocol-specific  
set of parameters that completely defines the services and  
mechanisms necessary to protect traffic at that security

protocol location. These parameters typically include algorithm identifiers, modes, cryptographic keys, etc. An SA is often referred to by its associated security protocol (for example, "ISAKMP SA", "ESP SA").

5       At the initiation of a secure connection between two network elements, they must first negotiate an ISAKMP SA to protect their further negotiations. This ISAKMP SA is then used in negotiating Protocol SA's. During the negotiation and establishment of Protocol SA's, a security parameter index (SPI)  
10 is generated for each SA. The negotiated SA's are typically stored in a security association database (SAD), and an SPI is used together with a destination IP address and a security protocol to uniquely identify an SA. Another database typically maintained by an IPsec-enabled element is a security policy  
15 database (SPD) which specifies the policies concerning disposition of all IP packets. Each IPsec-enabled interface typically maintains separate inbound and outbound databases (SPD and SAD).

20       In a wireless local area network (WLAN), which has become more and more popular, it is not uncommon for a mobile user to roam among different subnets or from one geographic area to another using different IP addresses. It has become increasingly desirable to support the ability of maintaining

secure connections without loss of data while a mobile client experiences a change of IP address. However, current IPsec architecture does not support such an IP address change without terminating the old connection and re-establishing a new one.

5 As a result, a roaming client would encounter inevitable network service disruptions, which is not only inconvenient for the client but also burdensome for the network due to overhead costs from repeated security negotiations.

One solution to the loss-of-connection problem is to adopt  
10 Mobile IP in an IPsec implementation. With this solution, a mobile client is assigned a relatively permanent Mobile IP address in its home network. When roaming into a foreign network, the client obtains a care-of IP address from a foreign agent and communicates with the rest of the world through the  
15 foreign agent. As shown in Figure 1, when it roams from Network 1 to Network 2, the mobile client has to maintain double tunneling to the Security Server in order not to lose connection. Mobile IP with double tunneling is highly inefficient and can be especially problematic for a resource-  
20 limited mobile unit. In addition, it takes considerable development effort to implement Mobile IP.

In view of the foregoing, it would be desirable to provide a mobility solution which overcomes the above-described

inadequacies and shortcomings.

#### **SUMMARY OF THE INVENTION**

According to the present invention, a technique for  
5 maintaining secure network connections is provided. In one  
particular exemplary embodiment, the technique may be realized  
as a method for maintaining secure network connections. The  
method may comprise detecting a change of address associated  
with a first network element. The method may also comprise  
10 updating at least one first security configuration at the first  
network element. The method may further comprise transmitting  
at least one secure message from the first network element to a  
second network element, wherein the at least one secure message  
comprises information associated with the change of address.  
15 And the method may comprise updating at least one second  
security configuration at the second network element based at  
least in part on the at least one secure message.

In accordance with other aspects of this particular  
exemplary embodiment of the present invention, a lookup of  
20 security associations may be not dependent on any destination  
address.

In accordance with further aspects of this particular  
exemplary embodiment of the present invention, the first network

element may be a mobile client and the second network element may be a security gateway.

In accordance with still further aspects of this particular exemplary embodiment of the present invention, the first network  
5 element and the second network element may be part of a virtual private network (VPN).

In accordance with additional aspect of this particular exemplary embodiment of the present invention, communications between the first network element and the second network element  
10 may be based on a security architecture for the internet protocol (IPsec). At least part of the communications between the first network element and the second network element may be based on an internet security association and key management protocol (ISAKMP). The second network element may identify at  
15 least one security association based on at least one cookie field in the at least one secure message.

In another particular exemplary embodiment, the technique may be realized by at least one signal embodied in at least one carrier wave for transmitting a computer program of instructions  
20 configured to be readable by at least one processor for instructing the at least one processor to execute a computer process for performing the method as recited above.

In yet another particular exemplary embodiment, the

technique may be realized by at least one processor readable carrier for storing a computer program of instructions configured to be readable by at least one processor for instructing the at least one processor to execute a computer  
5 process for performing the method as recited above.

In still another particular exemplary embodiment, the technique may be realized as a method for maintaining secure network connections. The method may comprise duplicating, between a second network element and a third network element,  
10 information associated with a secure network connection between a first network element and the second network element, wherein a lookup of security associations associated with the secure network connection is not dependent on any destination address. The method may also comprise replacing the second network  
15 element with the third network element in the secure network connection with the first network element. The method may further comprise sending at least one secure message from the third network element to the first network element.

In a further particular exemplary embodiment, the technique  
20 may be realized as a method for maintaining secure network connections. The method may comprise configuring a plurality of security gateways such that a lookup of security associations is not dependent on any destination address. The method may

further comprise sharing at least one security association among the plurality of security gateways.

In a still further particular exemplary embodiment, the technique may be realized by a system for maintaining secure network connections. The system may comprise means for detecting a change of address associated with a first network element, means for updating at least one first security configuration at the first network element, means for transmitting at least one secure message from the first network element to a second network element, wherein the at least one secure message comprises information associated with the change of address, and means for updating at least one second security configuration at the second network element based on the at least one secure message.

The present invention will now be described in more detail with reference to exemplary embodiments thereof as shown in the accompanying drawings. While the present invention is described below with reference to exemplary embodiments, it should be understood that the present invention is not limited thereto. Those of ordinary skill in the art having access to the teachings herein will recognize additional implementations, modifications, and embodiments, as well as other fields of use, which are within the scope of the present invention as disclosed

and claimed herein, and with respect to which the present invention could be of significant utility.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

5        In order to facilitate a fuller understanding of the present invention, reference is now made to the accompanying drawings, in which like elements are referenced with like numerals. These drawings should not be construed as limiting the present invention, but are intended to be exemplary only.

10       Figure 1 is a schematic illustration of a Mobile IP solution adopted in prior arts.

Figure 2 is a flow chart illustrating an exemplary method for maintaining secure network connections in accordance with an embodiment of the present invention.

15       Figure 3 is an illustration of an exemplary IPsec packet in accordance with an embodiment of the present invention.

Figure 4 is a block diagram illustrating an exemplary system for maintaining secure network connections in accordance with an embodiment of the present invention.

20       Figure 5 is a block diagram illustrating an exemplary implementation of High Availability in accordance with an embodiment of the present invention.

Figure 6 is a block diagram illustrating an exemplary



implementation of Group Mode Security in accordance with an embodiment of the present invention.

**DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENT(S)**

5       For illustration purposes, the technique for maintaining secure network connections in accordance with the present invention will be described below with specific reference to IPsec in tunnel mode. However, it should be appreciated that the technique is applicable to any secure network protocols  
10 regardless of the mode of operation. As used hereinafter, a "security gateway" refers to any intermediate or terminal system, such as a router, a firewall or a server, that implements IPsec protocols. A "mobile client" refers to a remote user or unit that communicates with a security gateway  
15 using IPsec protocols. One or more security gateways and mobile clients may form a security network system.

Referring to Figure 2, there is shown a flow chart illustrating an exemplary method for maintaining secure network connections in accordance with an embodiment of the present  
20 invention.

In step 200, Security Association (SA) lookup may be made independent of destination IP address system-wide.

In the context of IPsec in tunnel mode, an IPsec-processed

packet typically has a format as illustrated in Figure 3. The packet contains an Outer IP Header, an IPsec Header, an Inner IP Header and Other Data. The Inner IP Header, which contains the original source and destination addresses, and Other Data (e.g.,  
5 payloads) are protected with encryption. The information associated with the encryption and authentication is contained in the IPsec Header. And the Outer IP Header contains source and destination addresses for the tunnel endpoints. For inbound processing, a security gateway will use the destination IP  
10 address in the Outer IP Header, together with the Security Parameter Index (SPI) and the type of protocol as indicated in the IPsec Header, to look up the appropriate SA(s) in a local SA Database (SAD). The appropriate SA or SA bundles are then used in authenticating and decrypting the packet.

15 When SA lookup is made independent of destination IP address, SPI may be used to uniquely identify an SA within a protocol. This system-wide change may offer a number of advantages. For example, since inbound processing is no longer dependent on destination IP address, the change of outer IP  
20 address would not affect a security gateway's ability to locate the correct SA(s). Further, with the removal of dependency on destination IP address, the same SA may be shared among multiple IPsec tunnels and multiple nodes in a group. The resulting High

Availability and Group Mode Security will be described in more detail below.

In step 202, a mobile client may detect its own IP address change. As a mobile client moves into a different network or geographic area, its IP address may change to a different value. The change of address may also result from a switch of network adapters, e.g., from a WLAN to a LAN card or vice versa. As the mobile client detects the change, it may keep a record of the new address as well as the old address.

In step 204, the mobile client may update its own ISAKMP SAs and IPsec SAs with the new IP address.

Next, in step 206, the mobile client may use a current ISAKMP SA to send a NOTIFY message to a security gateway with whom the client has been maintaining a secure connection. The NOTIFY message may contain at least the client's old IP address and new IP address. The NOTIFY message may also include a sequence number to ensure reliable delivery and detection of duplicate packets. The contents of the NOTIFY message are securely protected by the ISAKMP SA encryption. The ISAKMP NOTIFY message may be subject to the same retry and timeout of other ISAKMP messages.

In step 208, upon receiving the NOTIFY message, the security gateway may locate the appropriate ISAKMP SA based on

the cookie fields in the ISAKMP header. The cookie fields uniquely identify the SA associated with the NOTIFY message. The appropriate SA may then be applied to process the secure NOTIFY message to extract the old and new IP addresses.

5        In step 210, the security gateway may then update its SADs based on the old and new IP addresses of the mobile client. According to embodiments of the invention, it may be more desirable to update the security gateway's SADs based on a secure NOTIFY message from the mobile client rather than based  
10 on inbound data with the new IP address. To update the outbound SAD or ISAKMP SAs using an outer IP header may expose the security gateway to denial of service (DoS) attacks since the outer IP header is not protected by integrity check such as Hashed Message Authentication Code (HMAC). Further, the  
15 security gateway might need to forward data to the client before any inbound data is received.

In step 212, after the security gateway is updated with the new IP address of the mobile client, the IPsec connection may be maintained. IP traffic can continue flowing in both directions  
20 between them without disruption. Once the mobile client receives data packets destined to the new IP address, it will know that the update of new IP address has succeeded.

Referring now to Figure 4, there is shown a block diagram

illustrating an exemplary system (400) for maintaining secure network connections in accordance with an embodiment of the present invention. The System 400 may be any network element (e.g., a remote unit, router or server) that implements IPsec protocols. The System 400, typically comprises a processor module 402, a storage module 404 and a transceiver module 406. The processor module 402 may be a central processing unit (CPU), micro-controller, digital signal processing (DSP) unit, or computer with packet-processing and hardware-control functions. The storage module 404 may be a storage device, such as a semiconductor memory, nonvolatile memory, hard drive disk, CD-ROM or similar, that is accessible by the processor module 402. Storage module 404 may hold data records including SADs, SPDs, and IP addresses, etc. The transceiver module 406 may be capable of transmitting and receiving data packets. In operation, the processor module 402 may follow the IPsec protocols including ISAKMP in accordance with the exemplary method described above. System 400 depicts the typical components of either a mobile client or a security gateway. As a mobile client, the processor module 402 may detect its IP address change, store the old and new addresses in the storage module 404, update the local SADs with the new address, and send an ISAKMP NOTIFY message, via the transceiver module 406, to a

security gateway. As a security gateway, the processor module 402 may receive the ISAKMP NOTIFY message via the transceiver module 406, look up the ISAKMP SA in the storage module 404 based on the cookie pairs in the NOTIFY message, decrypt the message with the ISAKMP SA, and update the local SADs based on the old and new IP addresses.

As mentioned above, removal of dependency on destination IP address makes it possible to achieve High Availability and Group Mode Security. These two implementations are described in connection with Figures 5 and 6.

Figure 5 is a block diagram illustrating an exemplary implementation of High Availability in accordance with an embodiment of the present invention. In Figure 5, there is shown a Mobile Client 500 maintaining a secure connection with a Security Server 502 via an IPsec Tunnel 52. When the IPsec connection is established between Mobile Client 500 and Security Server 502, a copy of the IPsec SAs and the ISAKMP SAs may be sent via a secure path 56 to a Security Server 504. During the life of the connection between Client 500 and Server 502, any changes in their security configurations may be securely duplicated to Server 504. In the same time, Server 504 may constantly monitor the operations of Server 502. When Server 502 fails, Server 504 may send an ISAKMP NOTIFY message to

Client 500 indicating the connection will be taken over by  
Server 504. Since Server 504 is up-to-date with all the  
security information concerning the connection between Client  
500 and Server 502, Client 500 will be able to decrypt the  
5 NOTIFY message and start forwarding traffic to Server 504  
without re-establishing an IPsec connection. And since there is  
no SA dependency on destination IP address, Server 504 should be  
able to communicate with Client 500 via IPsec Tunnel 54 in  
exactly the same way as Server 502 did. As a result, Client 500  
10 may experience minimal impact due to failure of Server 502.

Figure 6 is a block diagram illustrating an exemplary  
implementation of Group Mode Security in accordance with an  
embodiment of the present invention. Current IPsec is a point-  
to-point model. With the SA dependency on destination IP  
15 addresses, each connection between any two nodes has to be  
individually configured. For a system with N nodes, N being an  
integer, a total of  $N*(N-1)/2$  connections must be configured.  
As the number of nodes increases, the number of connections that  
have to be individually configured may increase very quickly.  
20 For example, for an organization with four branch offices, as  
shown in Figure 6, a total of six connections among the four  
security servers (A through D) must be configured. For a system  
with 8 nodes, 28 connections are to be configured. However,

with the removal of dependency on destination IP address, the same SA may be shared among multiple nodes in a group. Any traffic sent among the group nodes may be protected using the same SA. This may make configurations of a large number of  
5 branch offices much easier.

Functionalities in accordance with the above-described exemplary method may be achieved without physical modification to existing network hardware. Instead, the mobility solution in accordance with the present invention may be implemented through  
10 software and/or firmware upgrades.

At this point it should be noted that the technique for maintaining secure network connections in accordance with the present invention as described above typically involves the processing of input data and the generation of output data to  
15 some extent. This input data processing and output data generation may be implemented in hardware or software. For example, specific electronic components may be employed in a computer and/or communications network or similar or related circuitry for implementing the functions associated with the  
20 mobility solution in accordance with the present invention as described above. Alternatively, one or more processors operating in accordance with stored instructions may implement the functions associated with maintaining secure network



connections in accordance with the present invention as described above. If such is the case, it is within the scope of the present invention that such instructions may be stored on one or more processor readable carriers (e.g., a magnetic disk),  
5 or transmitted to one or more processors via one or more signals.

The present invention is not to be limited in scope by the specific embodiments described herein. Indeed, other various embodiments of and modifications to the present invention, in  
10 addition to those described herein, will be apparent to those of ordinary skill in the art from the foregoing description and accompanying drawings. Thus, such other embodiments and modifications are intended to fall within the scope of the following appended claims. Further, although the present  
15 invention has been described herein in the context of a particular implementation in a particular environment for a particular purpose, those of ordinary skill in the art will recognize that its usefulness is not limited thereto and that the present invention can be beneficially implemented in any  
20 number of environments for any number of purposes. Accordingly, the claims set forth below should be construed in view of the full breadth and spirit of the present invention as disclosed herein.